



Drilling, Rig Types, Drill String Components

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Engineering I (PTR 217)

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Previous Lecture

- Seismic Geophysical Survey
- Type of Seismic waves
- Seismic Procedure
- Type of Seismic Surveys
- 2-D Seismic Geophysical Survey Examples

Content

- Drilling
- Drilling Rig Types
- Drilling Rig Systems
- Drilling Rig System Components
- Drill String Components

Lecture Learning Outcomes

- By the end of this lecture, you will be able to:
- Understand the concept of drilling engineering.
- List the different types of drilling rigs.
- Differentiate between the different rig subsystems
- Recall the names of several rig components and their functions
- Recall the names of drill string components and their functions

Drilling

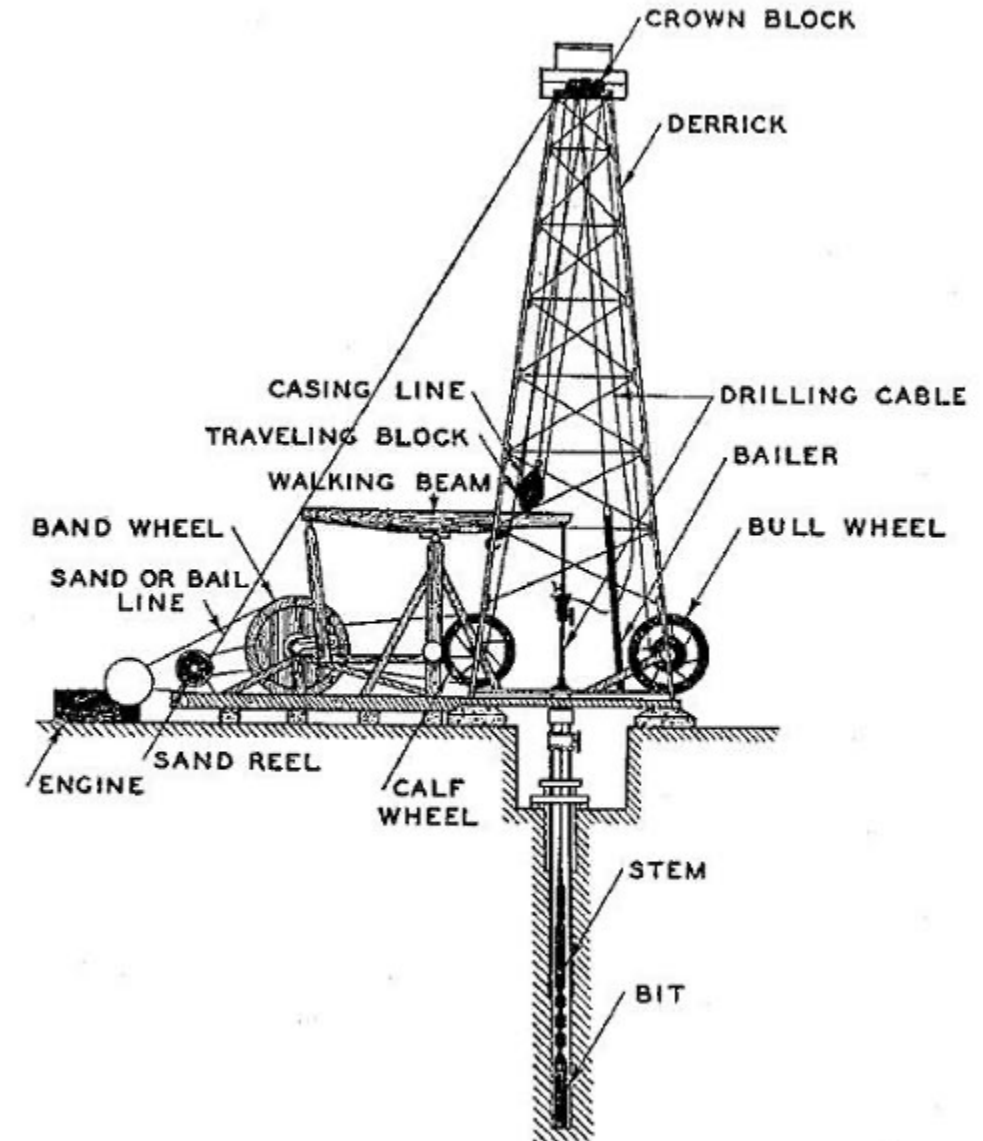
- **Petroleum Drilling Engineering:** Is the application of science and technology to drill Oil Wells, which are holes in the earth, made for the purpose of extracting oil and gas from hydrocarbon reservoirs.
- Extraction of oil and gas from a subsurface formation requires access to the resource. Drilling is one step in that direction. So, reservoir fluids are accessed by drilling a well and then preparing the well for the production or injection of fluids.
- Expenditure for drilling represents a large fraction of the total project's capital expenditure (CAPEX) (typically 20-60%), therefore an understanding of the techniques, equipment and cost of drilling is important.

Drilling Objectives

- A well could be drilled for many purposes which include:
 1. Collecting Earth Samples and Gathering Information
 2. Oil and Gas Production
 3. Water Production
 4. Fluids Injection (Water and Gas) for Pressure Maintenance and Sweeping.
 5. Disposal of Liquid Wastes and cuttings.
 6. Disposal of Gases such as CO_2 (Sequestration).

Cable Tool Drilling

- The first commercial oil well in Pennsylvania, was drilled with a cable tool rig.
- Cable tool rigs lift and lower a bit to pound a hole in rock formations
- As needed, pounding would be stopped so water and debris could be bailed from the hole with a “bailer” on a cable. Then the pounding resumed.
- Cable tool rigs could routinely drill from 25 ft per day up to 60 ft per day.
- Cable tool drilling, which is also known as percussion drilling, was used for all US fields in the 1800s.

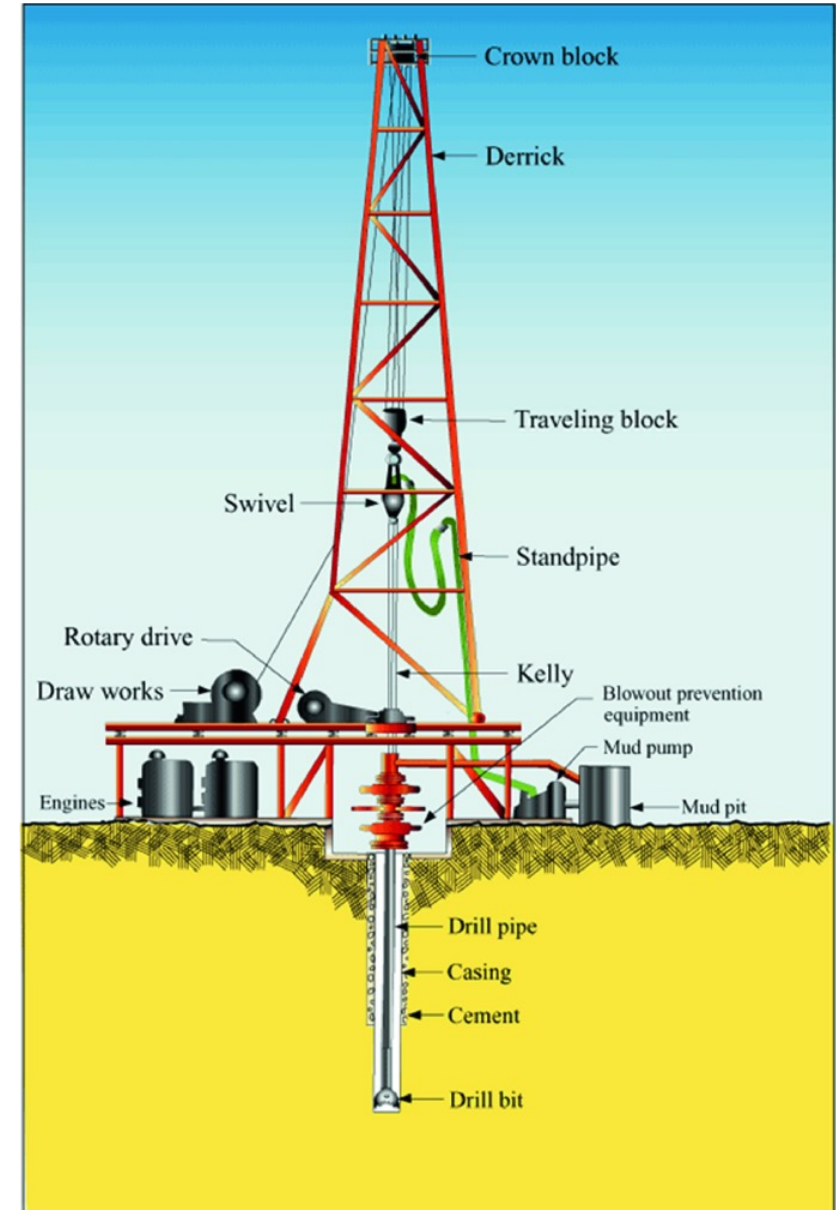


Disadvantages of Carble Tool Drilling

- The methods is slow (e.g. Rate of penetration).
- Drilling depth limitation.
- It does not prevent unstable rock from collapsing into the wellbore.
- It does not effectively control surface pressure.
- Consequently, the uncontrolled production of fluids, known as a blowout, was common.

Rotary Drilling

- The first person to use rotary drilling was a french civil engineering, which he used to drill a water well.
- A rotary drilling rig turns, or rotates, a bit on the bottom, which drills and creates the hole.
- A series of pipes are added to lower the bit to the bottom. When the bit is at the bottom, the driller starts rotating it using a rotating machine called the **rotary table**. As the bit's teeth, or cutters, rotate over the formation, they gouge or scrape the rock away.

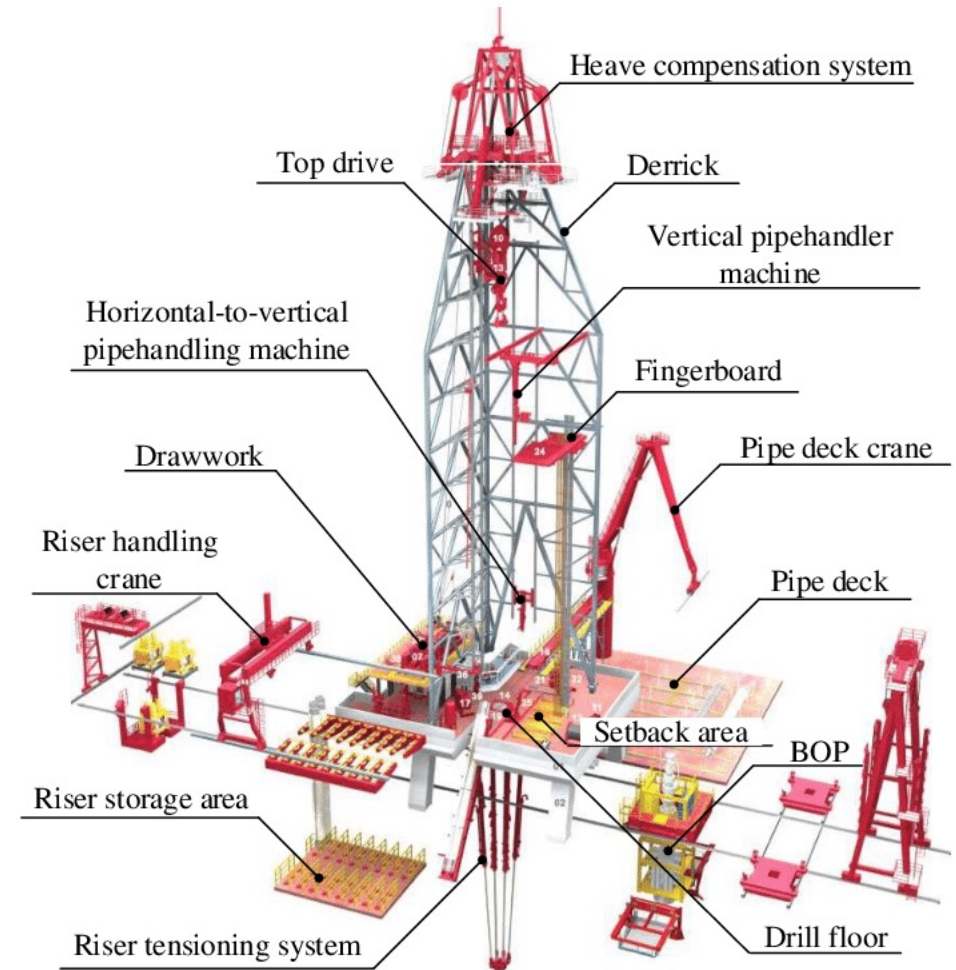


Rotary Drilling

- A rotary rig circulates fluid while the bit drills.
- A **powerful pump** can move fluid down the pipe to the bit and back through the
- annulus space to the surface. At the surface, equipment removes the cuttings,
- and the clean fluid is recirculated back down the pipe.
- Thus, with rotary drilling, **drilling does not have to stop in order to bail cuttings.**

Drilling Rig

- Oil well drilling rigs are mechanical structures consisting of many components such as the derrick, drawworks, rotary table and all associated equipment required to make holes in the ground in order to reach a predetermined hydrocarbon reservoir (i.e. a subsurface storage where oil and/or natural gas accumulate). They come in different types and structures.



Rig Types

1. **Onshore Rigs:** are those rigs that are used on land.
2. **Offshore Rigs:** are those rigs that are used in the oceans.



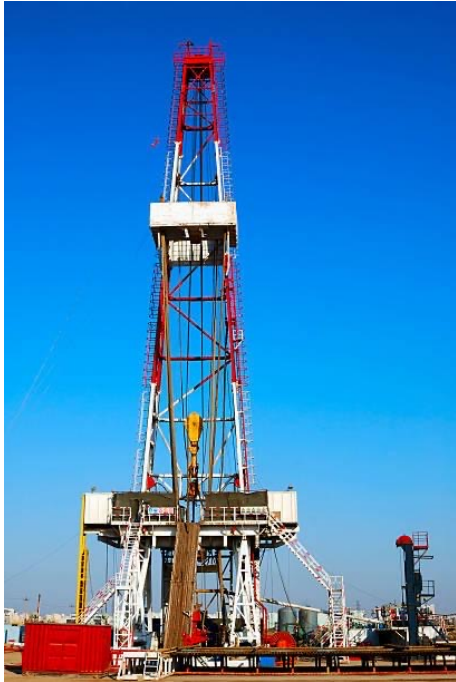
VS.



Onshore Rigs

- **Conventioanl Rigs:** Moved in pieces and assembled on location.

- **Mobile Rigs:** Mounted on a Truck.



Conventional Rig



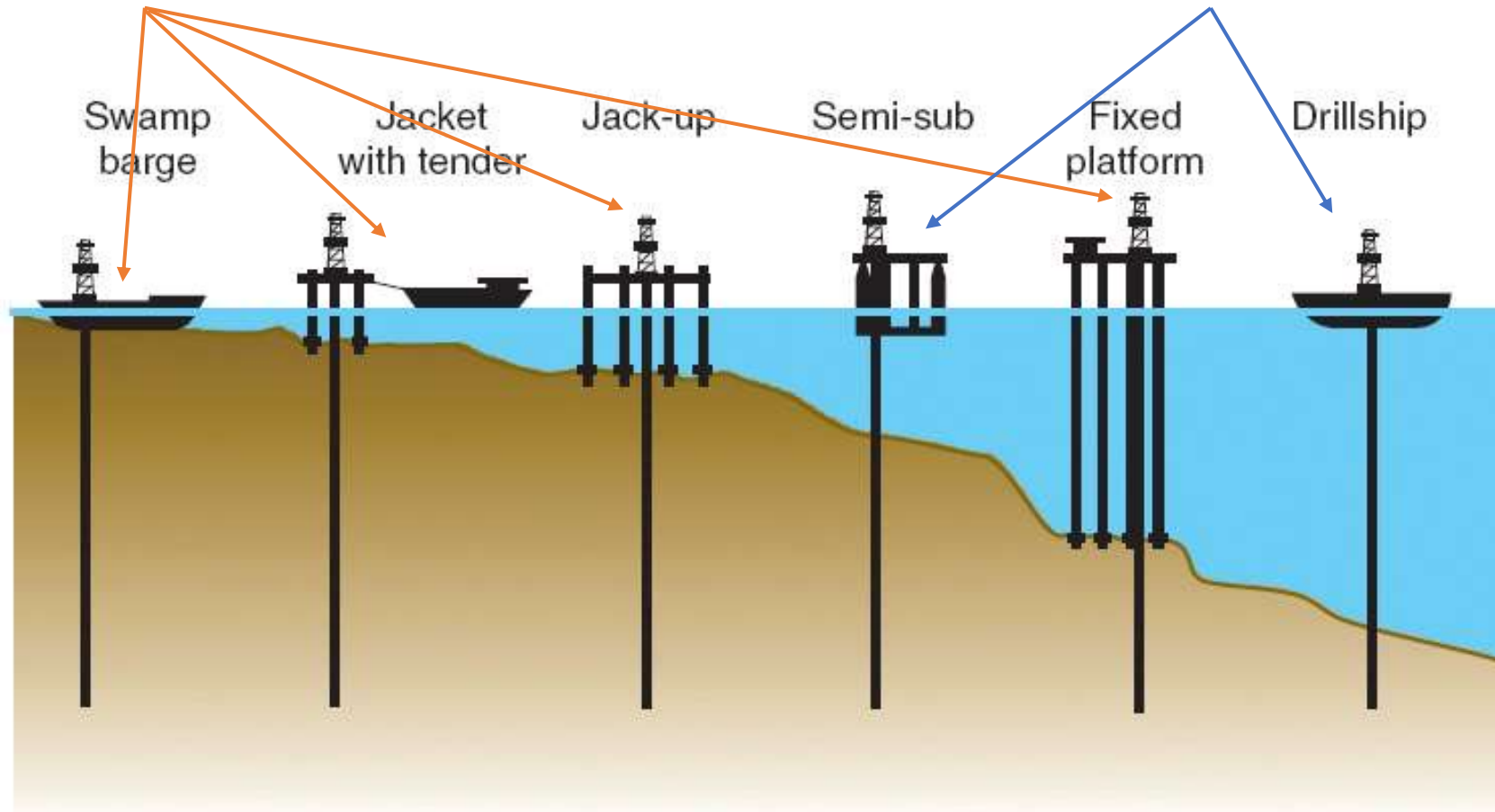
Jackknife Rig



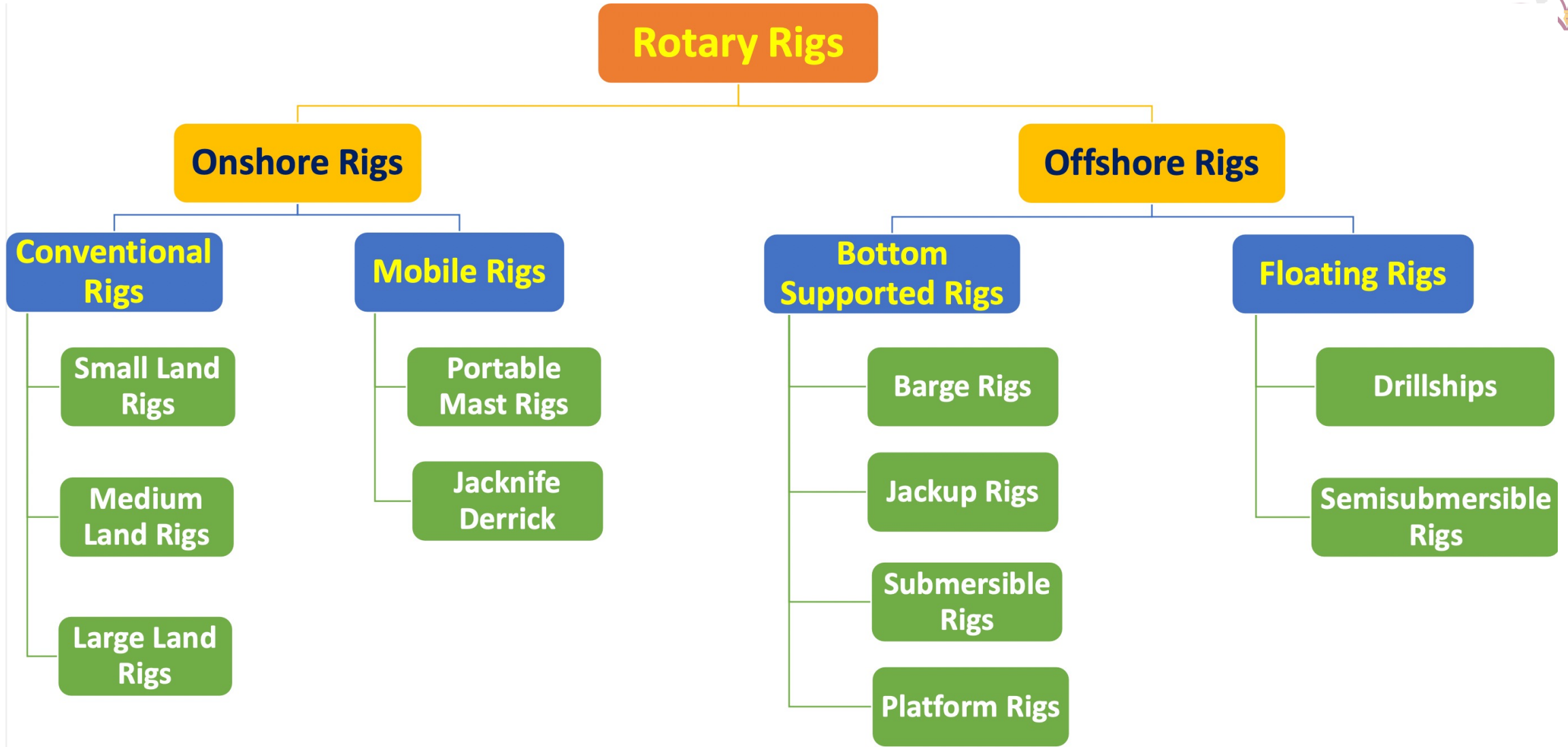
Portable Mast Rig

Offshore Rigs

- **Bottom-supported Rigs:** their footing reaches ocean floor.
- **Floating Rigs:** they float in the water and are stabilized using various mechanisms.



Rig Types

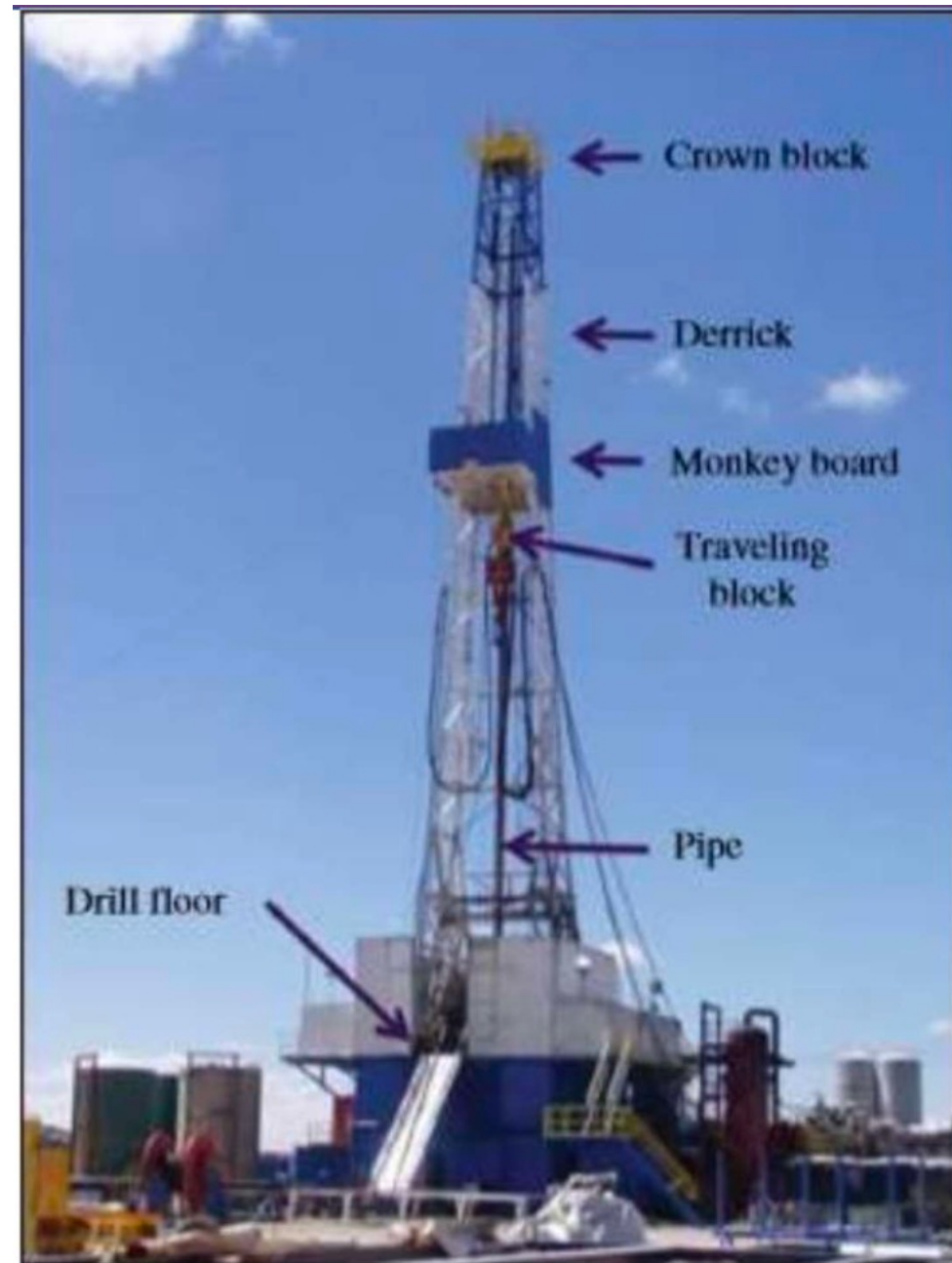


Rig Selection

- The type of rig which will be selected depends on a number of parameters, including:
 - Cost and Availability
 - Water depth of location (offshore).
 - Mobility/transportability (onshore).
 - Depth of target zone and expected formation pressure.
 - Prevailing weath/metocean conditions in the area of operation.
 - Experience of the drilling crew (in particular the safety record!).

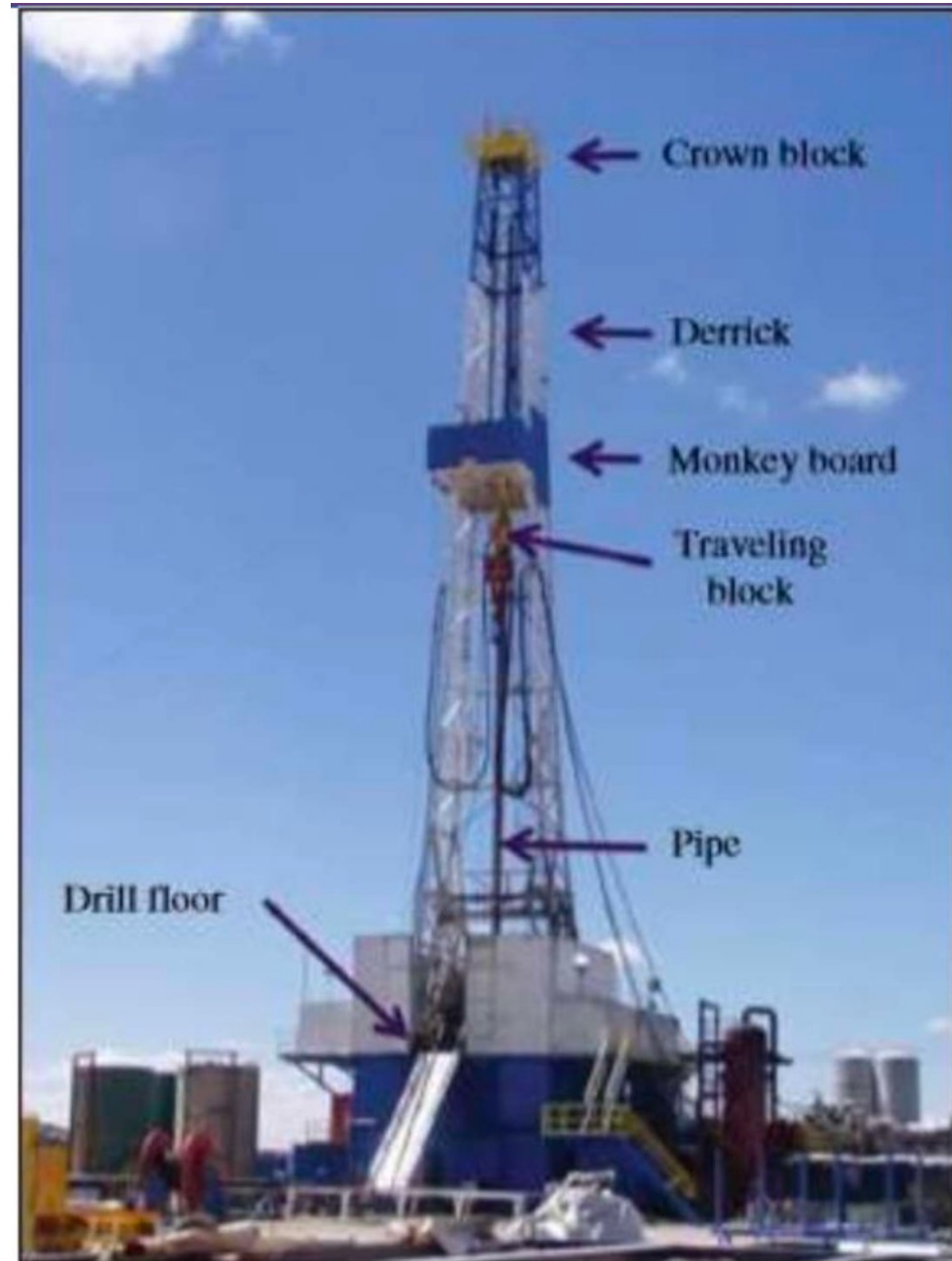
Rig Components

- **Crown Block:** The fixed set of pulleys (called sheaves) located at the top of the derrick or mast, over which the drilling line is threaded
- **Derrick:** The structure used to support the crown block and the drillstring of a drilling rig.
- **Monkey Board:** The derrickman's working platform. As pipe or tubing is run into or out of the hole, the derrickman must handle the top end of the pipe, which may be as high as 90 ft (27 m) in the derrick or mast. The monkey board provides a small platform to raise him to the proper height for handling the top of the pipe



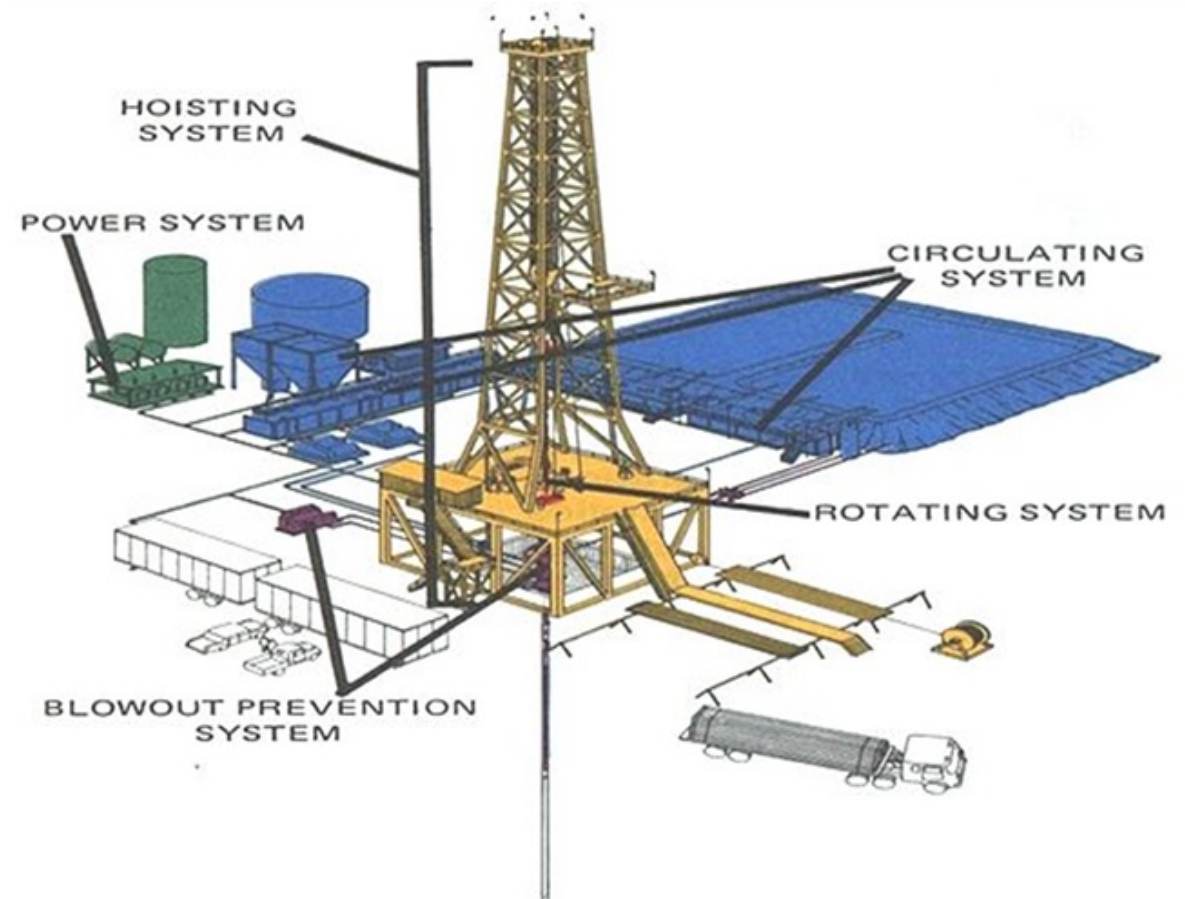
Rig Components

- **Travelling Block:** The set of sheaves that move up and down in the derrick. The wire rope threaded through them is threaded (or "reeved") back to the stationary crown blocks located on the top of the derrick.
- **Drill floor:** The relatively small work area in which the rig crew conducts operations, usually adding or removing drillpipe to or from the drillstring.



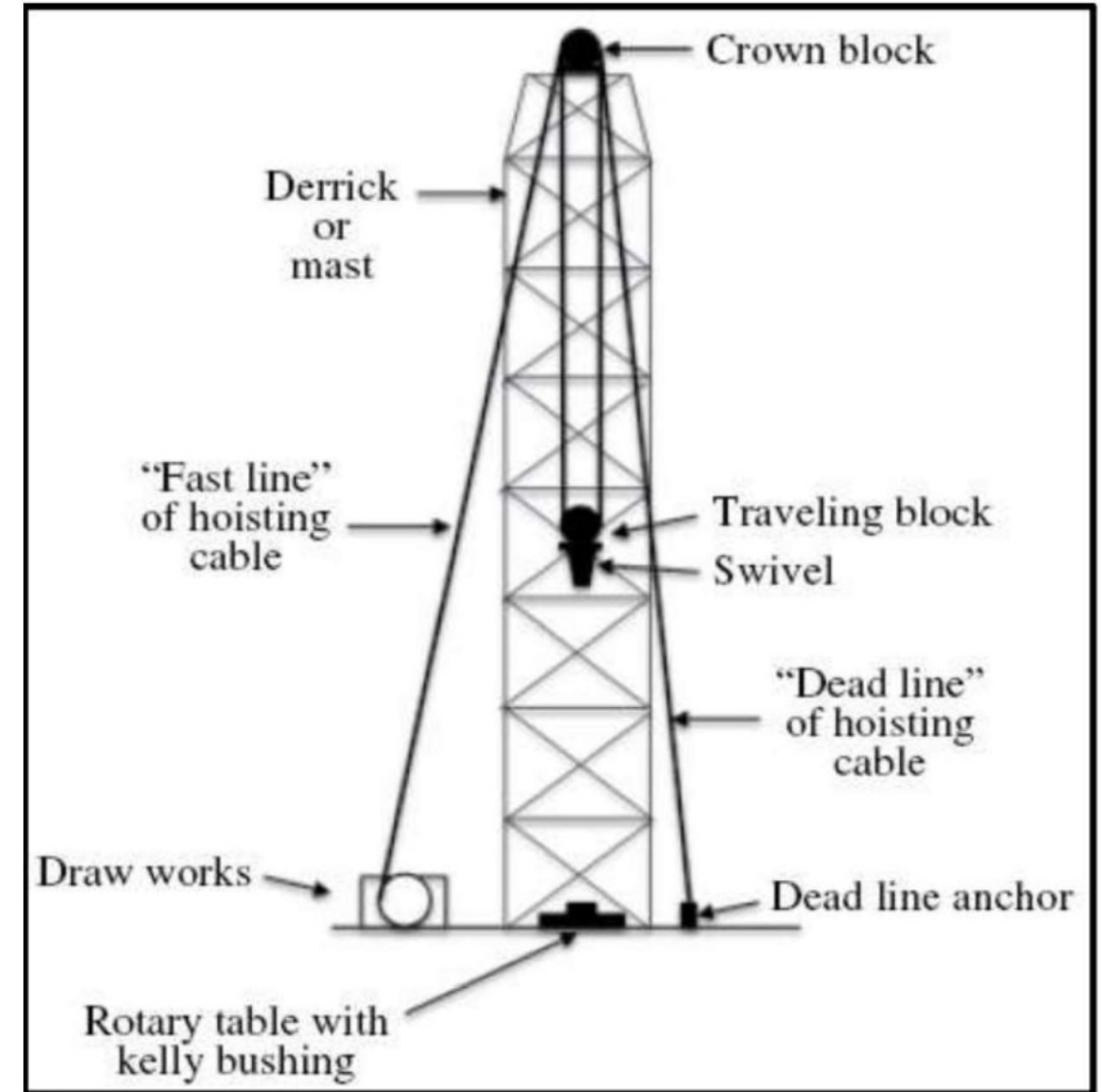
Rig Systems

- These individual pieces of equipment can however be grouped together into five subsystems.
- These systems are:
 - The **hoisting system**, to raise and lower the drill string.
 - The **circulation system**, to circulate drilling fluid or “mud”.
 - The **rotary system**, to rotate the drill string and hence the drill bit.
 - The **power system**
 - The **blowout prevention system**, for controlling the well especially during emergencies.



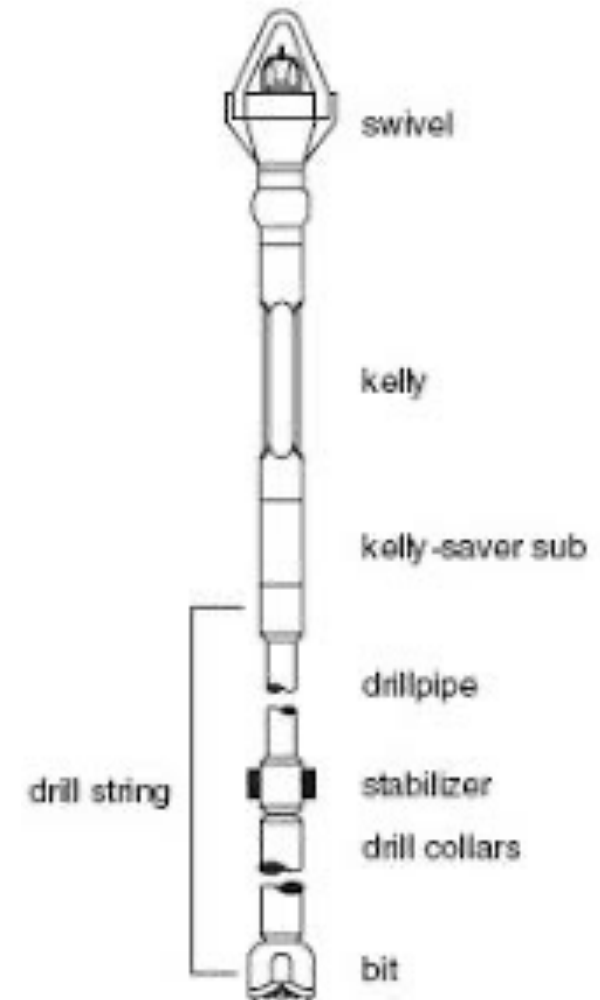
Hoisting System

- **Hoisting System:** The hoisting system is used mostly to move the strings of drill pipe or casing up and down in the wellbore.
- To repair or replace parts of the drill string, the crew must hoist or “trip” it out of the hole. During the trip, stands of the pipe are stored between the derrick floor and the monkey board. The monkey board board is where the derrickhand is stationed to guide the pipe. A stand of pipe is two or three pipe joints that are screwed together.



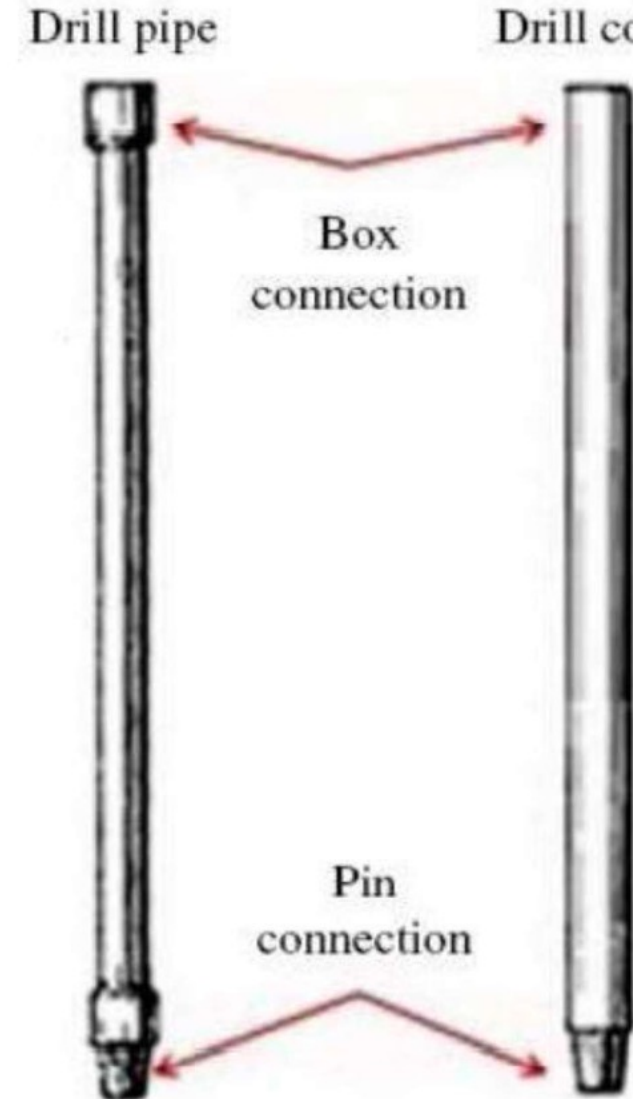
Drill String

- The drill string consists of:
 - Drill Pipes
 - Drill Collars
 - Drill Bit
 - Optional Attachments
- **Drill Stem:** is another term used in place of drillstring in some sources. It describes all the drilling components from the swivel down to the bit.



Drill String

- The drill string consists of:
 1. **Drill Pipes:** is the main component of the drill string, which forms the upper part of the drill string. It is a seamless pipe which is used to rotate the bit and circulate the drilling fluid.
 2. **Drill Collars:** are heavy-walled pipes that:
 - Place weight on the drill bit during drilling.
 - Keep the drill pipe in tension to prevent bending and buckling of the drill pipe
- Drill pipes and collars are rated by:
 - Size (outside diameter).
 - Weight per unit of length.
 - Grade (steel material and manufacturing process).
 - Connections.



Drill String

3. **Drill Bit:** the cutting element at the bottom of the drillstring, used to grind, break, or shear the rock at the bottom of the well.
- Rotary bits are either:
 - Roller-cone bits
 - Drag Bits/Fixed cutter bits



Roller Cone bit



Drag (PDC) bit

Drill String

- **Roller cone bits:** can be:

Mill tooth tri cone bits, steel teeth (soft formations).



Insert tooth tri cone bits, Tungsten carbide and button bits (hard formations).



Drill String

- **Drag Bits:** Drag bits can be

PDC (Polycrystalline Diamond Compact) discs bounded to tungsten carbide posts mounted on the surface of the bit. PDC bits are good for drilling hard formations.

Diamond Bits such as NDB (Natural Diamond Bits), TSP (Thermally Stable Polycrystalline), Impregnated Diamond bits.



Drill String

- **Optional attachments:** these are equipment that may be assembled and may include:
- **Stabilizer:** a drilling stabilizer is a piece of downhole equipment used in the Bottom Hole Assembly (BHA) of a drill string. It mechanically stabilizes the BHA in the borehole in order to avoid unintentional sidetracking, vibrations, and ensure the quality of the hole being drilled.



Stabilizer

Drill String

- **Jars:** a mechanical device used downhole to deliver an impact load to another downhole component
- **Shock subs:** are used to absorb vibrations and bit shock loads in drill collar strings.



Jars



Shock subs

Next Lecture

- Next lecture on Monday November 13th, 2023. at 09:00 in class L.104 we will discuss:
- Drilling Circulation System and Components
- Rotary System and Components
- Drilling Mud
- Functions of Drilling Mud
- Drilling Process